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Performance of Different Coating Batters and Frying Temperatures for Fried Fish Balls

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Abstract: The effects of yellow lentil flour, chickpea flour and their mixtures as batters on deep-fried fish balls were evaluated in the present study. The pH levels, viscosities and adhesion degrees of the batters and yields, frying loss, penetrometer values, diameters, moisture, oil content and sensorial properties of fish balls were determined for the different mixtures and frying temperatures. Yellow lentil flour, chickpea flour and their mixtures increased the quality of the battered fish balls after frying. Yellow lentil flour increased the yield and moisture values and decreased the frying loss and penetrometer values during deep-frying. Chickpea flour had better sensory properties in comparison to the control and yellow lentil flour. Frying temperatures generally did not affect the quality criteria. Only, low temperatures decreased the moisture loss from the coated fish balls during deep-frying. In conclusion, yellow lentil flour and chickpea flour were suggested as the batter materials to be used on fish balls.

Key words: Edible coating, yellow lentil flour, chickpea flour, fish ball, deep-frying, Turkey

INTRODUCTION

Legumes flours are important for food products in terms of nutritional and functional properties. However, there is limited information on the use of different flours such as yellow lentil flour and chickpea flour for the coating application. These flours have a high protein and starch amount. It was observed that the protein content and starch content were in the range of 28.7-31.5 and 46-47.1% for the lentil flours and 20.07-25 and 42.9-46.3% for the chickpea flour, respectively (Chung *et al*., 2008).

These components correlate with the viscosity in the batter as well as the moisture transfer, oil absorption and texture in the fried food. They reinforce the structure of coating and reduce the mass transfer between the food and the environment. The colours of these flours are also suitable for the coated and the fried food. The application of the lentil flour and the chickpea flour on the fish balls as the coating medium demonstrated more beneficial effects in comparison to wheat flour and corn flour. Similar results were also identified in various other studies. In addition, different ways of consumption of these flours were also emphasized (Debnath *et al*., 2003; Serdaroglu *et al*., 2005; Bajaj and Singhal, 2007). Bamdad *et al*. (2006) determined that concentrate lentil protein films had better colour values from peanut protein and soy protein. It was observed that the above mentioned film coating demonstrated good mechanical properties and solubility in comparison to other protein films. Kilincceker and Kurt (2010) emphasized that the chickpea flour had a better performance as a coating material on chicken nuggets in comparison to wheat flour and corn flour. It was reported that chickpea flour could be used in battering and breading systems for coating foods.

Deep fat frying is widely used in cooking methods which contributes desirable sensory attributes to the coated food. This process involves the transfer of heat from the surrounding oil to the food's interior together with the intake of oil to the food and the transfer of water from the food. At that juncture, more delicious and crispy products can be obtained from low taste and structured food (Saguy and Pinthus, 1995).

When the frying process is applied, the frying time and frying temperature should be appropriate. Otherwise, undesirable changes in the product structure may occur. Different temperatures may have different effects on the moisture content, oil content and sensorial properties such as colour and texture of the coated food after frying. In particular in low temperature, cooking in coated products with yellow lentil flour and chickpea flour which have high protein may be insufficient. Subsequently, the inner part frying and taste are not developed, sufficiently. At high temperatures, a hard product structure may also occur. The above mentioned conditions can directly affect the consumer choice

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(Mohamed *et al*., 1 998; Krokida *et al*., 2000). Thus in the product development stage, the selected materials and treatments should be appropriate for the quality of the coated product. In particular, the choice of materials which do not have negative effects on the physical, sensorial properties and yield values of the fish meats after frying is important. This is because fish meat is a sensitive product during processing (Sathivel, 2005; Kilincceker *et al*., 2009).

The present study evaluated some of the performance properties of the different batters from Yellow Lentil Flour (YLF) and Chickpea Flour (CF) used as the coating materials on the fish ball. In addition, it also investigated the effect of different temperatures on the coated fish balls.

MATERIALS AND METHODS

Fresh fish (*Rainbow trout*) were obtained from a local fish seller and stored 2±1°C until use (Adiyaman, Turkey). Yellow lentil flour (*Lens culinaris*) and chickpea flour (*Cicer arietinum*) were obtained from Ozmenler Food Co. (Izmir, Turkey). Bread crumbs and other ingredients were obtained from local markets in Turkey. Carboxymethylcellulose (CMC) was obtained from Smart Chemical Co. (Izmir, Turkey). Canola oil was used as the frying medium (Yudum, Yudum Food Co. Balikesir, Turkey). A mini fryer (Tefal, FF1024, China) with 1 L capacity was used for the frying operations. Fresh fish were eviscerated, beheaded and washed with chilled water by hand. They were boiled for 1 min in boiling water and then cooled to room temperature. Their skins and bones were removed and the remainder part was minced using a mincing machine. The mince was used to prepare the ball dough according to the following equation:

Fish ball dough: 1000 g mince+66 g bread crumb +
9.8 g salt+0.7 g black paper+
0.5 g bay leaf powder

The prepared fish balls were 28.85 mm in diameter. They were dipped in batters for 30 sec as shown in Table 1 and then allowed to drain for 1 min. Subsequently, each sample (4 pieces) was coated with an equal amount of bread crumbs and fried at 175, 180 and 185°C during 5 min. A batter formulation with no mixture addition was used as the control.

Determination of the properties of the coating materials: The particle size and starch content of the coating materials were determined according to Elgun *et al*. (1998).

Table 1: Batter equations (200 mL)

Mixture	Batter
100% YLF	47.8 g mix+0.2 g CMC+2 g salt+distilled water
2:1 YLF:CF	47.8 g mix+0.2 g CMC+2 g salt+distilled water
1:1 YLF:CF	47.8 g mix+0.2 g CMC+2 g salt+distilled water
1:2 YLF:CF	47.8 g mix+0.2 g CMC+2 g salt+distilled water
100% CF	47.8 g mix+0.2 g CMC+2 g salt+distilled water

YLF: Yellow Lentil Flour, CF: Chickpea Flour, CMC: Carboxymethylcellulose

The particle size was determined with a standard sieve. The total starch contents were also determined using a polarimeter. The conversion factor applied to starch was 5.4734 for the flours. The moisture content was determined gravimetrically by oven-drying at 105°C for 4 h. The protein amount of the coating materials was measured using the Kjeldahl analysis (AACC, 1995). The nitrogen to protein conversion factor was 6.25 for the flours.

Viscosity, pH and adhesion degree analysis of the batters: Viscosities of the different batters were measured at 25°C and in 100 rpm using a viscometer (RVDV-E, Brookfield, USA). The pH values were measured by using a pH meter (3 Star Orion, MA, USA). The adhesion degrees were determined by measuring the weight of the raw fish balls (X) and the weight of the coated fish balls prior to frying (Y) according to the following equation:

$$\text{Adhesion degree} = \left(\frac{Y - X}{Y}\right) * 100$$

Yield, frying loss, penetrometer value and diameter analysis of the coated fish balls after frying: The yield and frying loss parameters were determined by measuring the weight of the raw fish balls (X), the weight of the coated fish balls prior to frying (Y) and the weight of the coated fish balls after frying (Z) according to the formula given below. A standard penetrometer with a needle having a 52.5 g load (Yuksel Kaya machine, Turkey) was used to evaluate the hardness in the fried fish balls. The needle was left to free fall from the same distance for each sample. The penetration depth was read as the mm after 2 sec of penetration. The diameters were determined by using an electronic digital calliper (Yamayo, India). Four fish balls were used for each replication:

$$\text{Yield} = \left(\frac{Z}{X}\right) * 100, \text{ Frying loss} = \left(\frac{Y - Z}{Y}\right) * 100$$

Moisture and oil analysis of the coated fish balls after frying: The moisture content of the samples was determined at 105±1°C for 4-6 h and the oil content was ascertained using the Soxhlet extraction method according to the guidelines proposed by AOAC (2000).

Sensorial analysis: Ten semi-trained judges assessed the sensory properties by using the hedonic scale for judging the criteria such as the appearance, colour, odour, taste-flavour and texture for the purpose of acceptability. The average score of these parameters was deemed the overall acceptability. The different values in the scale indicated the following reactions: 1: extreme dislike, 2: very much dislike, 3: moderate dislike, 4: slight dislike, 5: neutral, 6: like slightly, 7: like moderately, 8: like very much and 9: like extremely (Gokalp *et al*., 1999).

Statistical analysis: The pH values, viscosity and adhesion values of the batters were analyzed by the one-way Analysis of Variance (ANOVA) followed by the Duncan test. The experimental design was a completely randomized factorial model (5×3), containing five types of batters and three variations of the frying temperature with two replications of each treatment. The data were subjected to the Analysis of Variance (ANOVA) and the obtained results were expressed as the mean±Standard Deviation (SD). Any differences amongst the samples were compared using the Duncan's multiple-range test at $p<0.05$ level with the Statistical analysis system program (SPSS, Chicago, IL, USA).

RESULTS AND DISCUSSION

Properties of the coating materials: The particle sizes of the coating materials are shown in Table 2. The particle size of the flours affects the viscosity and adhesion degree of the batter which is prepared from these flours. Fine particles have a more homogeneous viscosity and are more adhesive in comparison to coarse particles. The yields as well as the moisture rates are higher in the coated food with these flours, creating a smooth and homogeneous bubbly surface on the food. As a result, the bread crumbs have a higher particle size in comparison to the other flours. In practice, the dry breading materials are classified under three groups: coarse, medium and fine (Dyson, 1992).

According to this classification, the bread crumbs were medium while the YLF and CF were fine (Table 2). The chemical properties of the flour that are significant for the batters are shown in Table 3. YLF has the lowest moisture level as 8.1%. The highest protein was in YLF as 26.4% and the highest starch was in bread crumbs as 67% while YLF and CF were the same, approximately. Chung *et al.* (2008) determined the moisture, protein and starch within a range of 8.6-8.8, 28.7-31.5 and 46-47.1% for the lentil flours, respectively.

Table 2: The particle size distribution of coating materials

Materials	<0.125 mm (%)	>0.212 mm (%)	>0.35 mm (%)
YLF	16.50	41.23	-
CF	10.10	45.60	10.00
Bread crumb	9.02	53.02	20.01

Table 3: The some chemical properties of coating materials

Materials	Moisture (%)	Protein (%)	Starch (%)
YLF	8.1	26.4	50.9
CF	9.9	22.7	50.5
Bread crumb	10.1	10.8	67.0

YLF: Yellow Lentil Flour, CF: Chickpea Flour

These values were obtained at ranges of 7.4-7.6, 20.7-25 and 42.9-46.3% for the chickpea flour, respectively. The moisture, protein and starch contents in the present study were approximately close to the above mentioned studies (Table 3). However, these contents may vary according to the species. Bread crumbs had the lowest protein and the highest starch content because they were made from wheat flour. The results of the moisture values were similar with the study of Grodner *et al.* (1991) which determined the values as 8.65-11.35% for the batter mixes. The protein values were higher in comparison to the values obtained as 4.25-15.75% in the present study. In addition, the results of the present study also agreed with the previous studies which were expressed as a high protein and high starch content for better coating processes (Kulp and Loewe, 1990; Gennadios *et al*., 1997).

The pH, viscosity and adhesion values of the batters: Effects of the mixtures on the pH values, viscosity and adhesion degrees were significant at a level of $p<0.01$. As shown in Fig. 1 and 2, the pH value of the control was higher in comparison to the others while the viscosity and adhesion degrees were lower in the control batter. The lowest pH value was in the batters in the ratio of 1:1 YLF:CF and 100% CF (Fig. 1). The higher viscosities were in the batters in the ratios of 2:1 YLF:CF and 1:1 YLF:CF while the higher adhesion degrees were found in the batters of 100% YLF, ratios of 1:1 YLF:CF and 1:2 YLF:CF (Fig. 2). The pH values were decreasing, while there was an increase in the CF rate in the batters. There was an increase in the viscosity degrees with lower levels of CF. However, the highest viscosity value was found in the batter in the ratio of 1:1 YLF:CF while the lowest was found in the batter in the ratio of 1:2 YLF:CF rate. There was an increase in the adhesion degree with CF in the YLF:CF mixtures. A high pH value in batters containing a large amount of YLF can be connected with the high protein rate in YLF. The increase in the viscosity degrees and adhesion degrees were associated with the protein and starch content in YLF and CF. The viscosity values and adhesion degrees increased in comparison to the

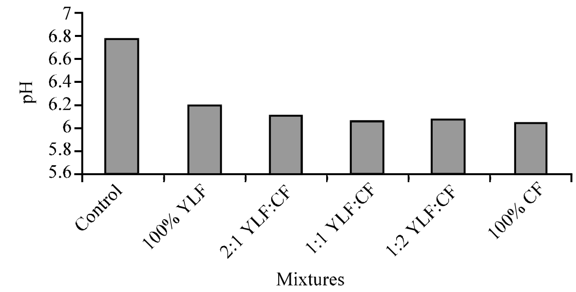

Fig. 1: pH values of batters prepared with different flour mixes

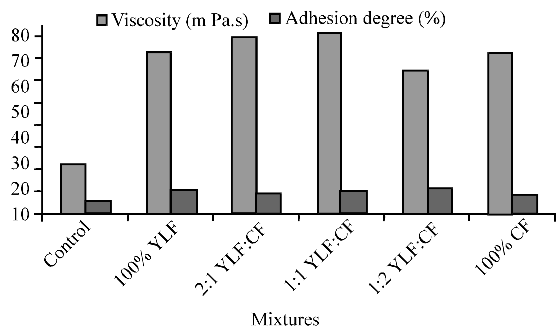

Fig. 2: Viscosities and adhesion degrees of batters prepared with different flour mixes

control group because of their water binding capacities (Fig. 2). The viscosity values and adhesion degrees in the batters relate to the water binding capacities of the dry materials. The ratio of protein and starch in the flours are important factors for the water binding capacity of the dry materials. High protein and high starch increase the water binding capacities of the batters which are prepared with these dry materials. Thus, there was an increase in the viscosities and adhesion degrees in batters which were prepared from YLF and CF. The results of the viscosities and adhesion degrees were similar to the previous studies that reported an increase in the viscosity and adhesion with an increase of components such as protein and stach in the batter (Kulp and Loewe, 1990; Gibney *et al*., 1999; Kilincceker and Kurt, 2010).

Yield, frying loss, penetrometer and diameter values of the coated fish balls after frying: The coating materials and mixtures significantly affected the yield, frying loss, penetrometer values and diameter values of the fish balls after frying ($p<0.01$). However, the effect of the frying temperatures was not significant on these values ($p>0.05$, Table 4). The yield values in the coated samples increased with an increase of YLF in the mixtures. The frying loss decreased with the control, 100% YLF and 2:1

Table 4: The effects of batter mixtures and frying temperatures on yield, frying loss, penetrometer and diameter values in coated fish balls after frying

Parameters	Yield (%)	Frying loss (%)	Penetrometer values (mm)	Diameters (mm)
Batter mixture				
Control	86.92 ± 1.64^{c}	17.24 ± 1.39^{b}	25.25 ± 2.33^{a}	29.62 ± 0.24^{b}
100% YLF	91.64 ± 1.60^{a}	17.43 ± 0.82^{b}	19.53 ± 3.41^{b}	30.21 ± 0.17^{a}
2:1 YLF:CF	90.69 ± 0.51^{ab}	17.28 ± 0.66^{b}	20.81 ± 2.79^{b}	30.23 ± 0.35^{a}
1:1 YLF:CF	89.63 ± 3.40^{ab}	19.39 ± 2.59^{a}	24.56 ± 1.43^{a}	30.45 ± 0.17^{a}
1:2 YLF:CF	89.32 ± 0.83^{c}	19.41 ± 1.28^{a}	23.51 ± 0.83^{a}	30.32 ± 0.27^{a}
100% CF	88.89 ± 1.61^{bc}	19.82 ± 0.33^{a}	25.50 ± 1.46^{a}	30.31 ± 0.23^{a}
Frying temperature (°C)				
175	89.58 ± 2.55^{a}	18.34 ± 2.35^{a}	23.21 ± 3.04^{a}	30.11 ± 0.35^{a}
180	89.42 ± 1.72^{a}	18.29 ± 1.40^{a}	23.75 ± 2.82^{a}	30.17 ± 0.38^{a}
185	89.55 ± 2.52^{a}	18.65 ± 1.33^{a}	22.62 ± 3.51^{a}	30.30 ± 0.33^{a}

YLF: Yellow Lentil Flour; CF: Chickpea Flour; $^{a-c}$The statistical differences among samples

YLF:CF. The penetrometer values were lower in the samples coated with 100% YLF and 2:1 YLF:CF. The diameter values of the frying balls were high according to the initial diameter (28.85 mm). The diameters were lowest in the control group while the other samples were similar to each other (Table 4). A high yield and low frying loss in the samples coated with a large amount of YLF depended on the fine particle size, low moisture and high protein in this flour in comparison to the other materials. Thus, YLF adhered and degraded more on the surface of the fish balls in comparison to CF during deep frying. It created a stronger coat and reduced the moisture loss and particle break from the surface during frying. Thus, the frying loss decreased with an increase in the yield.

Kilincceker and Kurt (2010) observed that in general, the yield values were approximately similar with the results as 87.41-88.97% for the chicken nuggets which were coated with the chickpea flour and wheat flour batters. The high yield in the sample coated with large amounts of YLF may be related with a high rate of protein. In addition, the frying loss was indicated at a range of 21.10-23.90% as observed by Kilincceker and Kurt (2010). However, it was at a more lower range (17.24-19.82%) in the present study.

The penetrometer values were low in the samples containing a large amount of YLF because of the high protein content. The high protein caused the formation of a hard crust on the fish ball surfaces after frying. Even if the samples had a soft inner, the hard crust on their surface made it difficult to sink the penetrometer needle. These values were higher in comparison to the previous study values which were determined as 13.01-13.78 mm for the chicken nuggets fried and coated with batters of different flours (Kilincceker and Kurt, 2010). The reason for the high values in the present study is connected with the usage of fish meat. Fish meat is softer in comparison to chicken meat because of the muscle tissue. Thus, the penetrometer needle can sink more in the fish balls in comparison to the chicken nuggets. As noted in the present study, batters with larger amounts of CF increased the softness of the fish balls after frying.

The diameters of the samples coated with YLF and CF were larger in comparison to the control group because of a high adhesion degree. The amounts of coating on the sample surface were also higher in comparison to the control during deep frying. Thus, the losses and the higher diameter values were obtained according to the diameters of the control and initial diameter. There was no study in literature which dealt with the value of the diameter on the coated chicken balls or meat balls. Normally, the diameters of many foods decrease after frying. This is an undesirable phenomenon by the manufacturer as it is an indication of shrinkage. Diameters should be big for the general appearance as well as the consumer preferences (Kulp and Loewe, 1990). Diameters of fish balls in the present study increased owing to a swell of proteins and starches in the structure of the flours during deep frying.

Moisture and oil values of the coated fish balls after frying: Initially, the moisture and oil content of the fish ball dough were 69.3 and 4.5%, respectively. However, the moisture content generally decreased while the oil content increased in the samples after coating and deep-frying. The batter mixtures had a significant effect at a level of $p<0.05$ and $p<0.01$ on the moisture and oil values of the samples after frying (Table 5). In addition, the frying temperatures also affected the moisture values ($p<0.05$) but not the oil values ($p>0.05$). The highest moisture values were in the samples coated with the control, 100% YLF, 2:1 YLF:CF and 1:1 YLF:CF. When the YLF increased, the moisture values also increased in the samples during frying. The oil values were found to be higher in comparison to the control (Table 5). However, the differences in the effects of the flour mixtures were not found significant ($p>0.05$). The moisture content decreased with an increase in the temperature. The highest moisture content was 53.22% after frying at 175°C (Table 5).

High moisture in the samples containing a large amount of YLF depended on the fine particle size and high protein as expressed in the yield and frying loss. YLF adhered more on the surface of the fish balls and formed a strong coat during frying. Consequently, YLF decreased the moisture transfer from the fish balls. High moisture at a low temperature results in less damage of the coating materials and the fish meat structure. Particularly, the protein and starch in the coating structure were less damaged, thereby forming a strong structure at this temperature. Thus, the moisture transfers from the fish

Table 5: The effects of batter mixtures and frying temperatures on moisture and fat in coated fish balls after frying

Parameters	Moisture (%)	Oil (%)
Batter mixture		
Control	52.63 ± 0.73^{abc}	11.86 ± 0.77^{a}
100% YLF	53.54 ± 0.31^{a}	10.31 ± 0.61^{b}
2:1 YLF:CF	53.20 ± 0.89^{ab}	10.34 ± 0.82^{b}
1:1 YLF:CF	52.75 ± 0.41^{abc}	10.38 ± 0.61^{b}
1:2 YLF:CF	52.16 ± 1.19^{c}	10.63 ± 0.78^{b}
100% CF	52.35 ± 0.56^{bc}	10.49 ± 0.56^{b}
Frying temperature (°C)		
175	53.22 ± 0.66^{a}	10.59 ± 0.80^{a}
180	52.74 ± 0.80^{ab}	10.77 ± 0.90^{a}
185	52.36 ± 0.86^{b}	10.64 ± 0.89^{a}

YLF: Yellow Lentil Flour; CF: Chickpea Flour; $^{a-c}$The statistical differences among samples

balls also decreased. A juicy structure in the fish balls was obtained owing to less decay of the fish tissue. The results of the oil content showed that the values of the samples coated with the batters of YLF, CF and their mixtures were higher in comparison to the control group as also with the viscosities and adhesion degrees. These batters created efficient barriers against the oil absorption. Thus, the oil absorption decreased in the samples coated with batters during frying. Kucukoner and Kilincceker (2007) determined a decrease in the moisture loss and fat absorption in the chicken drumsticks coated with different flours during deep frying. In another study, the blending of chickpea flour and gelatinized starch reduced the oil content of the food during frying (Debnath and Bhat, 2000). Similarly, Serdaroglu *et al.* (2005) observed a high moisture content in the meat balls prepared with lentil flour in comparison to the other samples after cooking.

Sensorial values of the coated fish balls after frying: Effects of the batter mixtures were significant at a level of $p<0.01$ on the sensory properties. However, the frying temperatures did not have a significant effect on the sensorial values ($p>0.05$, Fig. 3). The sensory scores were generally lower in the control group in comparison to the other samples. The sensory scores generally increased with an increasing CF in the batters. The highest sensory properties were found in the samples coated with 100% CF (Fig. 3).

Samples with a high level of CF formed a more golden yellow colour and a slightly rough structure. This was because CF has a more reddish colour as well as a large particle size. In the present study, the panellists were positively affected. This resulted in a rise in their scores. However, the typical smell and taste of YLF decreased the scores of these properties in the samples coated with the YLF batters. In terms of the texture values, the samples coated with the CF batters were liked more. This was because of less moisture and a softer crust in comparison

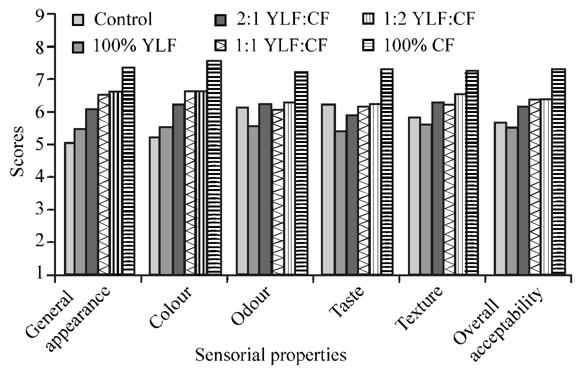

Fig. 3: The effect of batter mixtures on sensorial values in coated fish balls after frying

to the samples coated with the YLF batters. Thus, the sample could be chewed easily. In conclusion, it was observed that while the sensory values were at levels of acceptable or likely, the CF had an increased overall acceptability level. The results were generally similar to the results in the literature related to the battering and breading materials based on the flours or other coating materials (Gennadios *et al*., 1997; Khalil, 1999; Fiszman and Salvador, 2003; Kilincceker *et al*. 2009; Kilincceker and Kurt, 2010).

CONCLUSION

Yellow lentil flour, chickpea flour and their mixtures performed effectively to increase the quality of the battered fish balls. Yellow lentil flour increased the yield and moisture while it decreased the frying loss and penetrometer value in the fish balls after frying. However, the chickpea flour affected the sensory properties of the fish balls more positively. In addition, low temperatures decreased the moisture loss from the fish balls during deep frying. As a result, yellow lentil flour and chickpea flour are a suitable alternative to produce a wide variety of good quality battered fish balls with good sensory acceptability at low temperatures.

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